

Observation of pulsar B1929+10's extreme radio fluctuation event

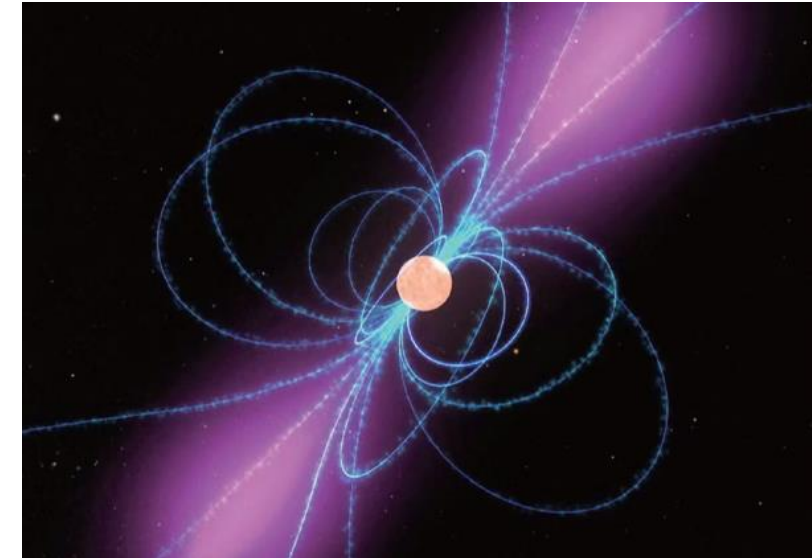
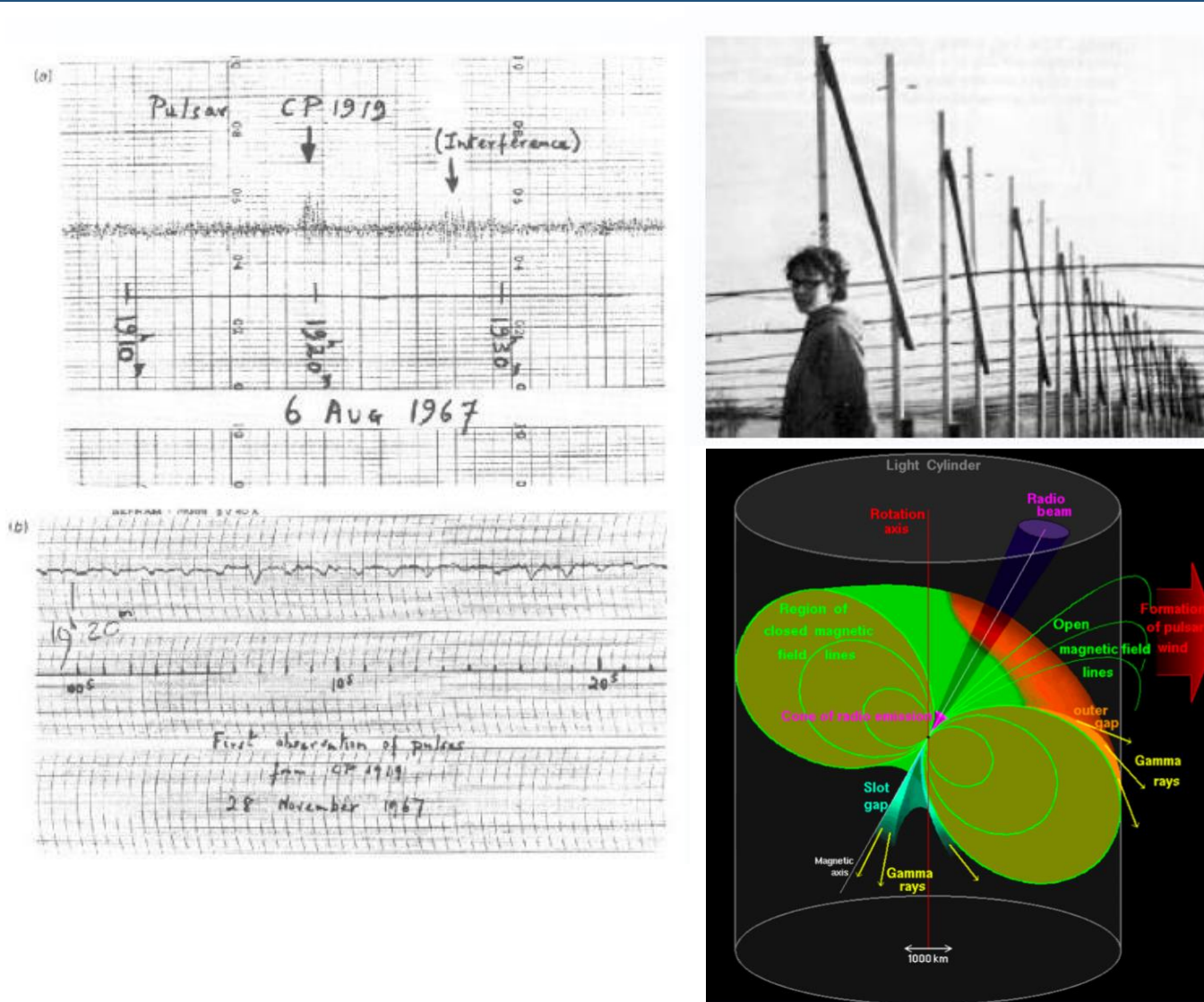
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Guiyang, July 4, 2026

- Brief introduction of pulsars
- Extreme radio fluctuation event (ERFE)
- Variation in the radio flux across time and frequency
- Measurement of the time of arrival (ToA).
- Scintillation effects
- Origin of the ERFEs
- Conclusions

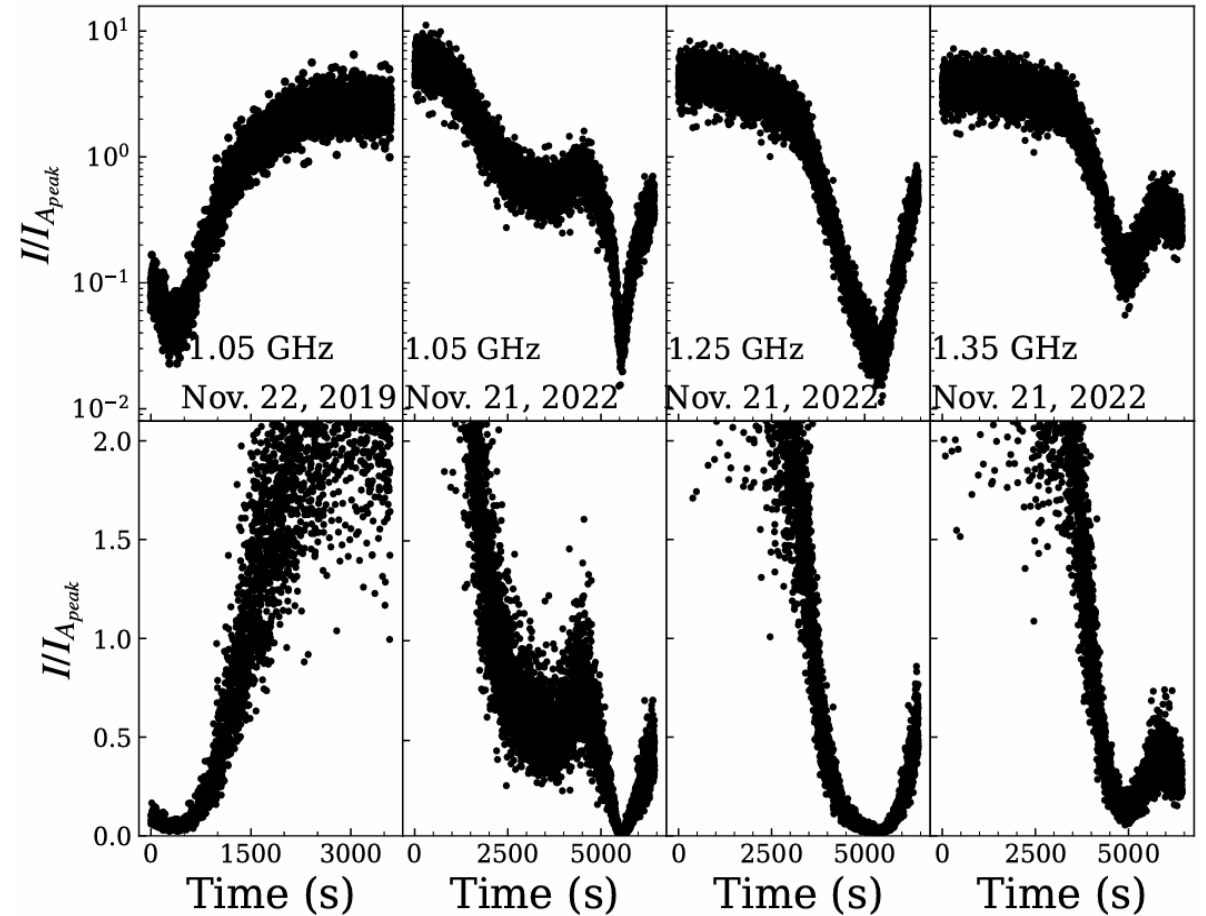
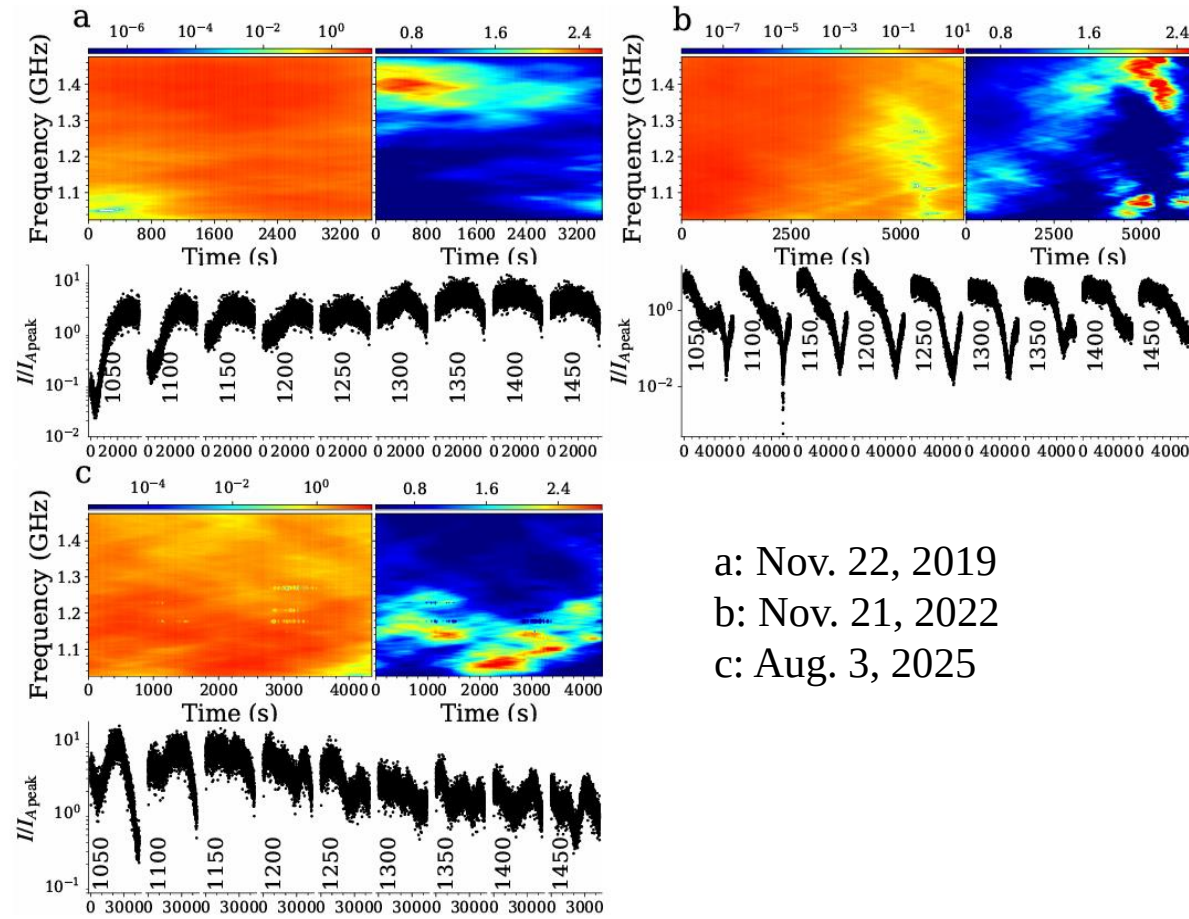
Introduction



NASA

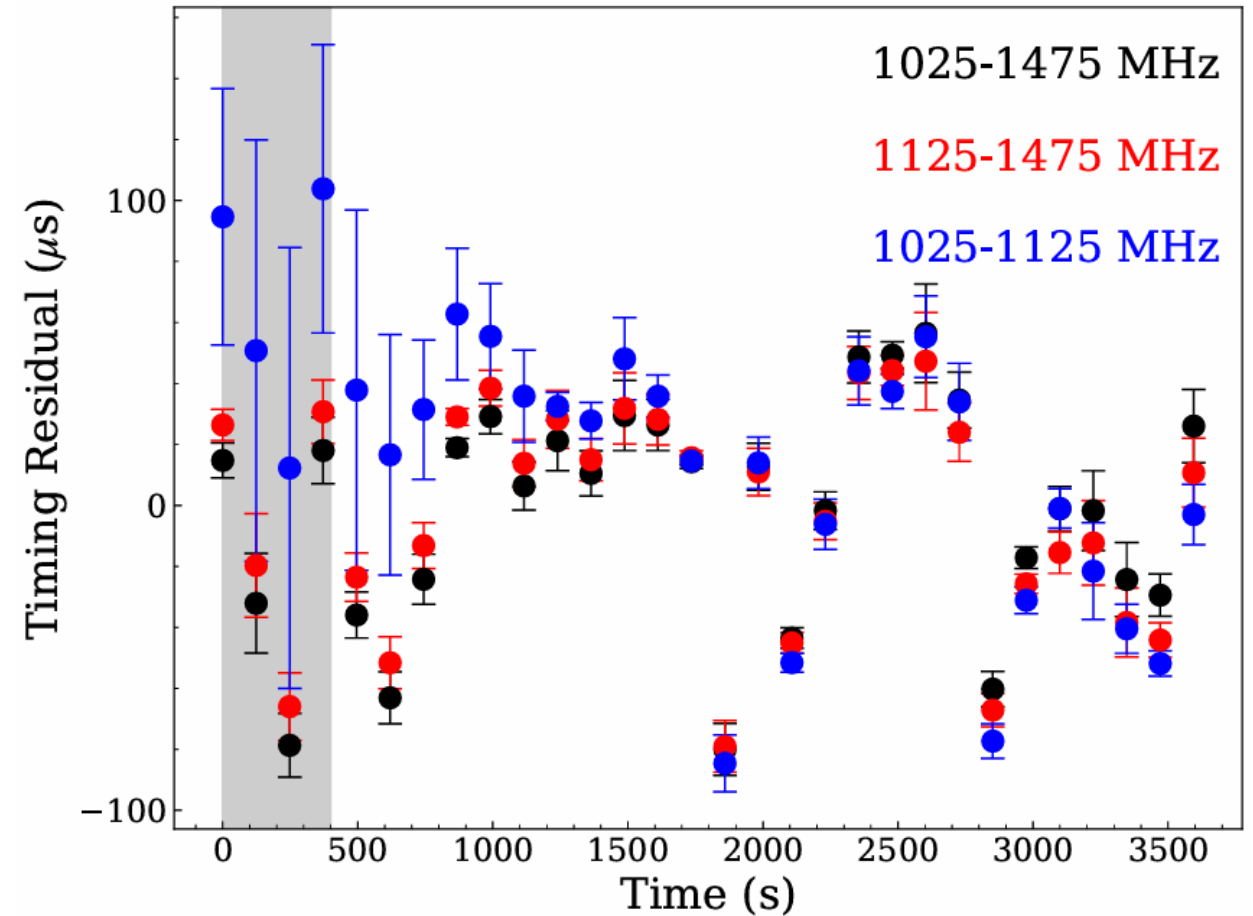
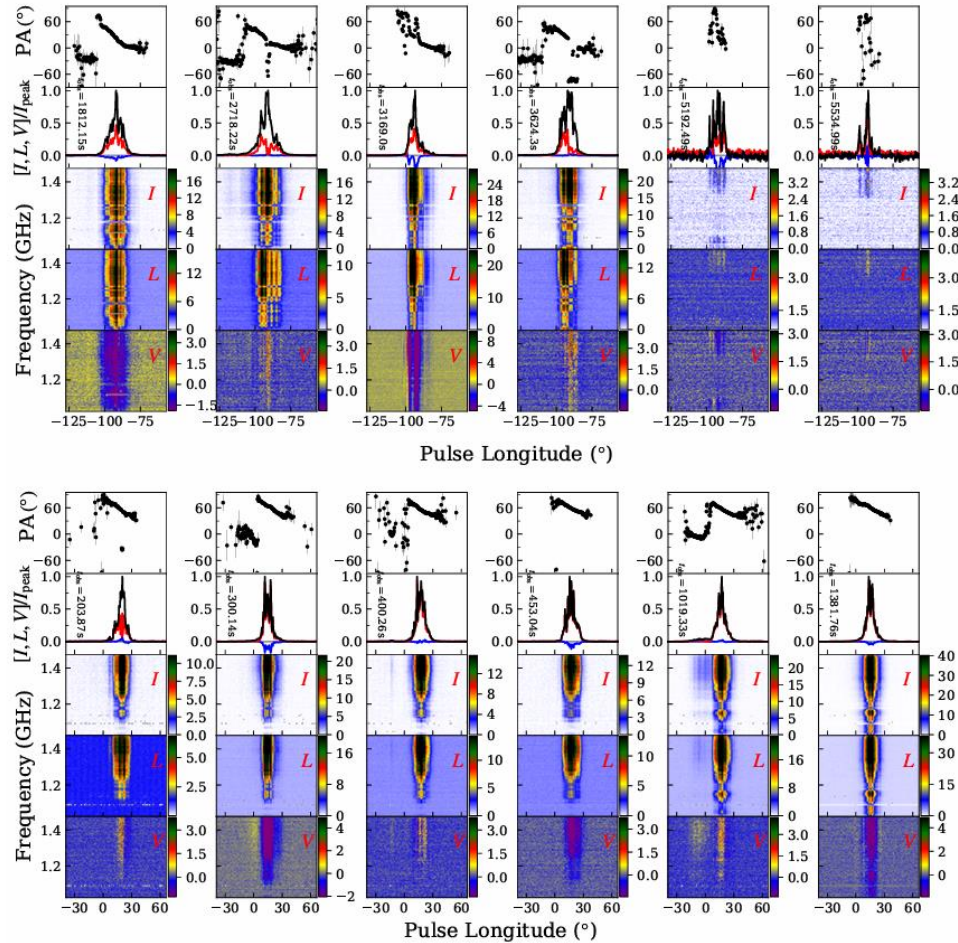
- Pulsars serve as natural laboratories for testing fundamental physics and constraining the equation of state.
- Pulsars as probes of the interstellar medium

Dynamic spectrum and light curve



- I. This dramatic fluctuation event was first identified on Nov. 21, 2022.
- II. A similar dramatic fluctuation in radio signals was observed on the archived data of Nov. 22, 2019.
- III. However, there was no detection in the follow-up observations.

Radio emission state and ToA



- I. Radio emission states in the single pulse have been **completely changed** in two epochs.
- II. The time of arrival of the pulse over 2 minutes exhibits a significant delay at **1.025-1.125 GHz** on November 22, 2019.

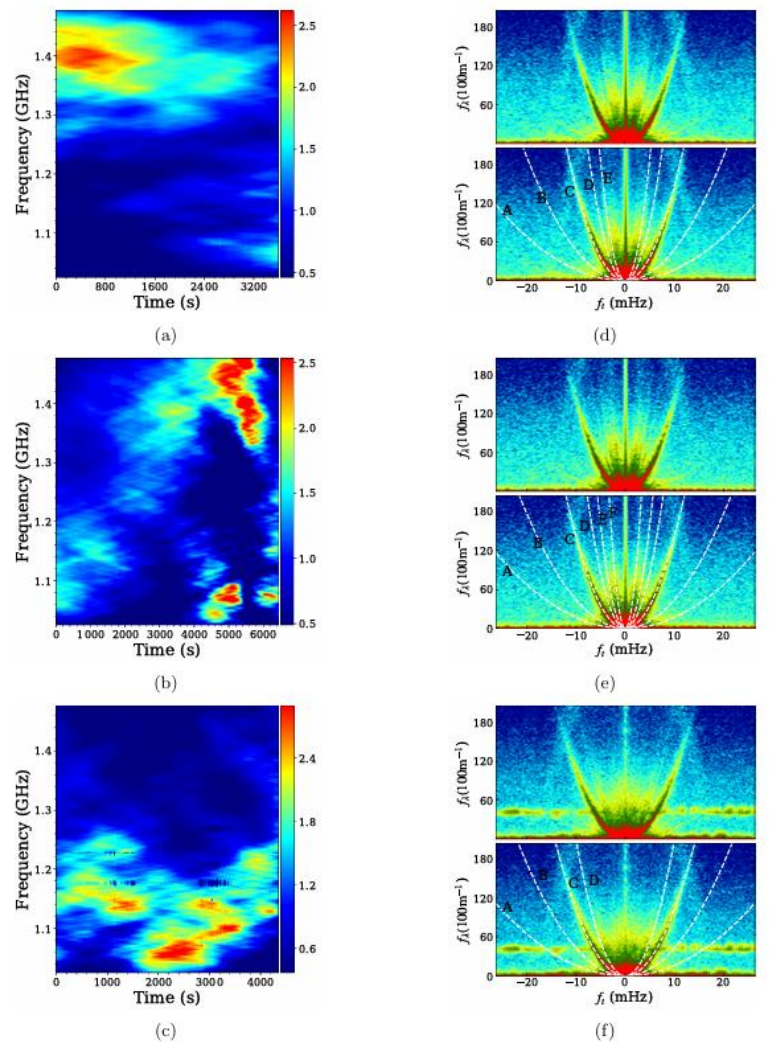


Table 2. Measured Arc curvatures from November 22, 2019

Arc Candidate	Curvature ($\text{m}^{-1} \text{mHz}^{-2}$)	Error ($\text{m}^{-1} \text{mHz}^{-2}$)
A	15.72	± 2.050
B	46.90	± 0.698
C	144.25	± 3.570
D	354.13	± 4.952
E	752.78	± 12.283

Table 3. Measured Arc curvature from November 21, 2022

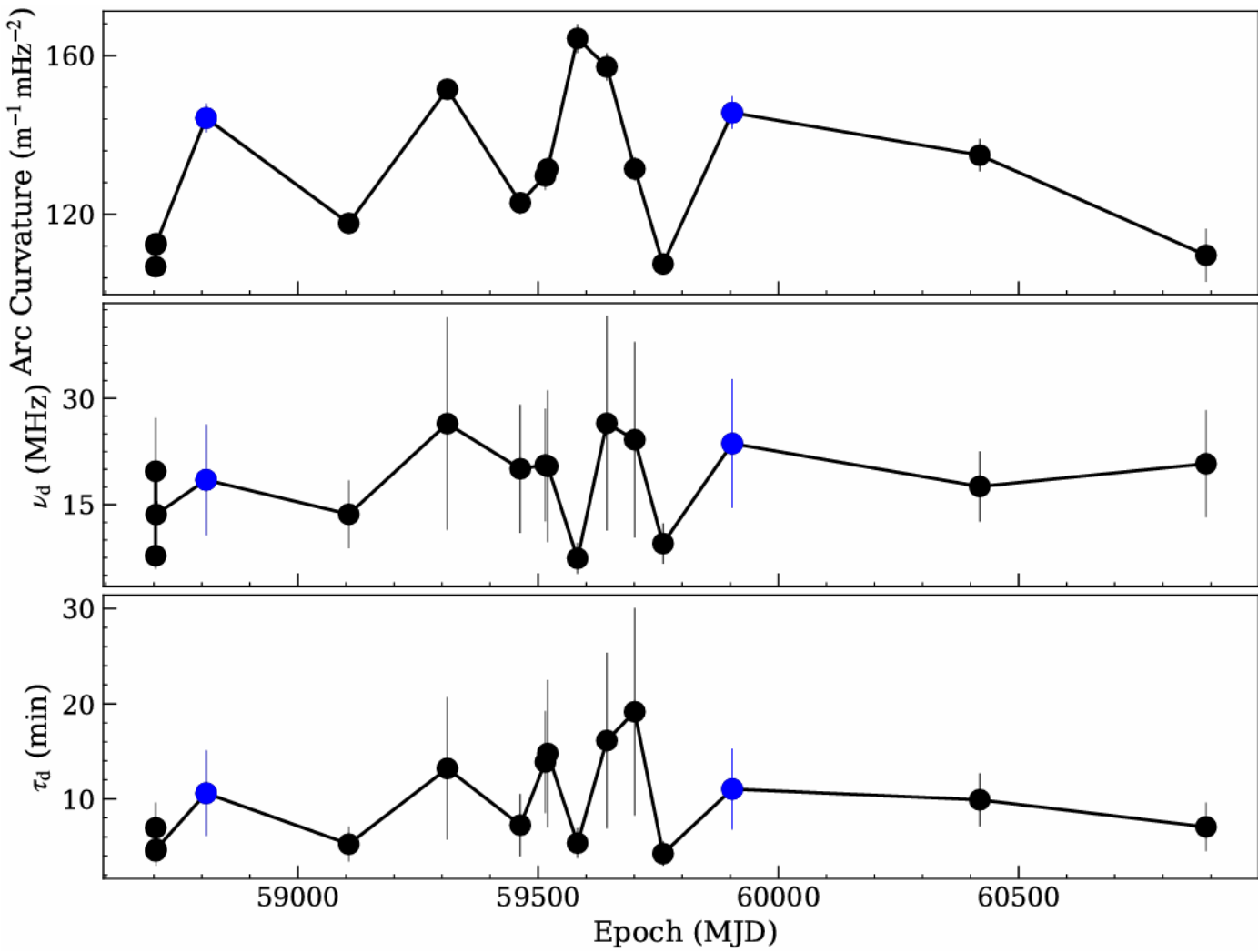
Arc Candidate	Curvature ($\text{m}^{-1} \text{mHz}^{-2}$)	Error ($\text{m}^{-1} \text{mHz}^{-2}$)
A	16.51	± 1.292
B	43.79	± 4.481
C	145.62	± 3.990
D	344.98	± 2.203
E	651.57	± 6.515
F	1953.53	± 22.118

Table 4. Measured Arc curvature from August 3, 2025

Arc Candidate	Curvature ($\text{m}^{-1} \text{mHz}^{-2}$)	Error ($\text{m}^{-1} \text{mHz}^{-2}$)
A	15.71	± 0.651
B	35.53	± 2.819
C	109.68	± 6.670
D	218.66	± 4.679

I. Scintillation intensity has remarkably changed
II. The curvature of the **brightest Arc** shows a dramatic fluctuation

Scintillation effects

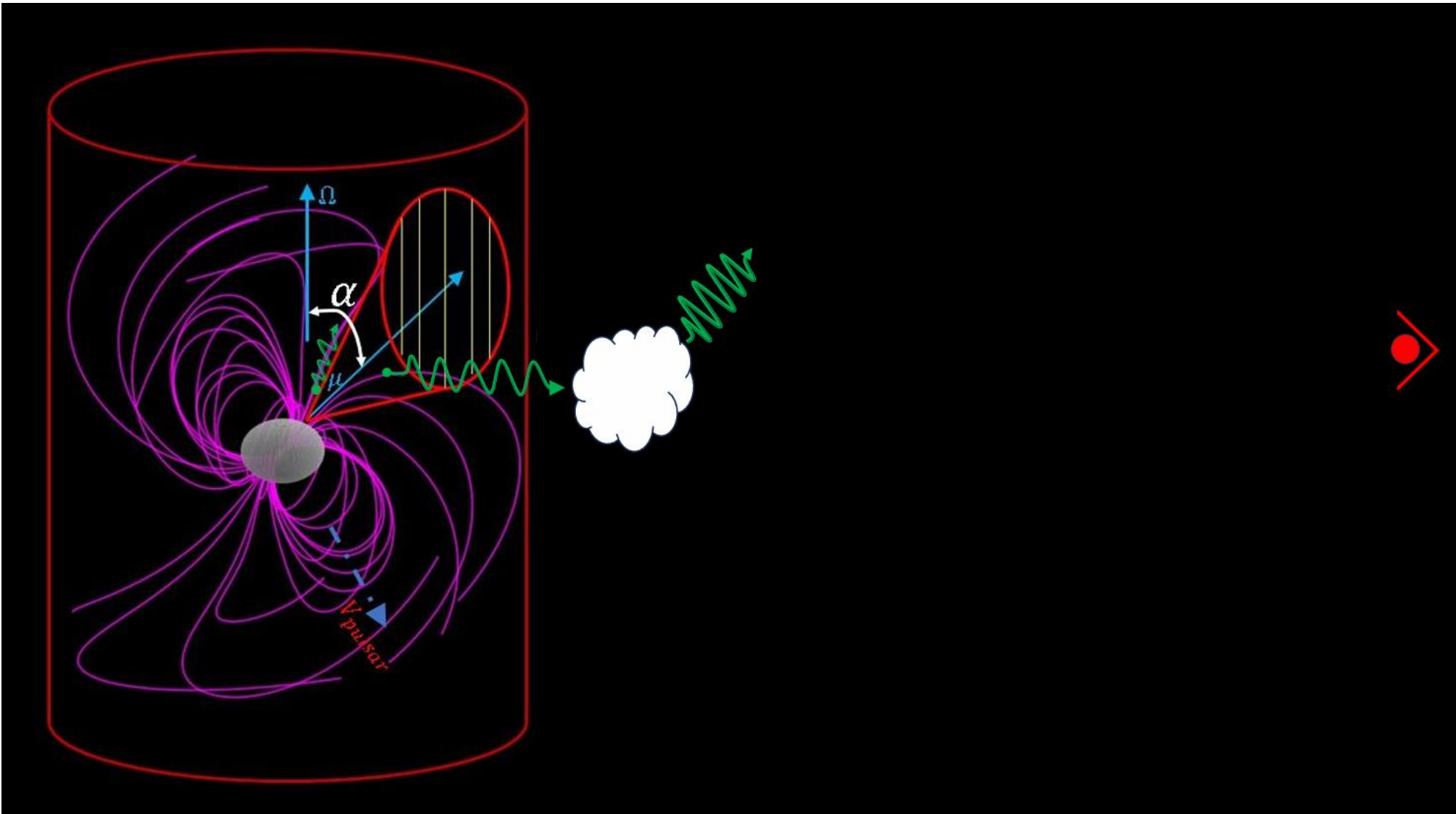


Date/MJD	Arc Curvature ($\text{m}^{-1} \text{mHz}^{-2}$)	ν_d (MHz)	τ_d (min)
2019-08-09/58704	106.83 ± 2.64	7.78 ± 1.850	4.53 ± 1.07
2019-08-09/58704	112.32 ± 2.78	19.71 ± 7.510	6.95 ± 2.65
2019-08-10/58705	112.63 ± 2.48	13.61 ± 5.030	4.70 ± 1.74
2019-11-22/58809	144.25 ± 3.57	18.49 ± 7.820	10.60 ± 4.48
2020-09-14/59106	117.76 ± 2.59	13.64 ± 4.790	5.24 ± 1.84
2021-04-07/59311	151.50 ± 2.03	26.44 ± 15.00	13.20 ± 7.50
2021-09-06/59463	122.92 ± 2.71	20.05 ± 9.050	7.24 ± 3.27
2021-10-28/59515	129.68 ± 3.57	20.60 ± 7.950	13.87 ± 5.36
2021-11-01/59520	131.44 ± 2.90	20.41 ± 10.70	14.77 ± 7.74
2022-01-03/59582	164.32 ± 3.63	7.41 ± 2.170	5.35 ± 1.57
2022-03-05/59643	157.14 ± 3.47	26.48 ± 15.14	16.13 ± 9.22
2022-05-02/59701	131.44 ± 2.90	24.16 ± 13.81	19.16 ± 10.90
2022-06-30/59760	107.51 ± 2.37	9.51 ± 2.860	4.24 ± 1.28
2022-11-21/59904	145.62 ± 3.99	23.62 ± 9.050	11.03 ± 4.23
2024-04-19/60419	134.91 ± 4.08	17.56 ± 4.960	9.90 ± 2.80
2025-08-03/60890	109.68 ± 6.67	20.77 ± 7.540	7.05 ± 2.56

The measured curvature of the brightest Arc has dramatic fluctuation across a period of 6 yr, which may be due to the annual variation in the pulsar’s elongation

Physical mechanism

1. Highly dense plasma cloud
2. Pulsar's outflow interacts with the Pulsar wind, causing an inhomogeneous region.



- At two epochs, the extreme radio fluctuation events exhibit distinct features across time and frequency.
- Measurement of the ToAs and the results of the interstellar scintillation for this pulsar suggest that the scintillation effects are unlikely to be responsible for the dramatic fluctuation.
- The proposed physical mechanism that relates to the pulsar's outflow can account for the dramatic radio events
- The observation of the ERFEs and their underlying applications in the pulsars' radio emission could shed light on pulsar astronomy.